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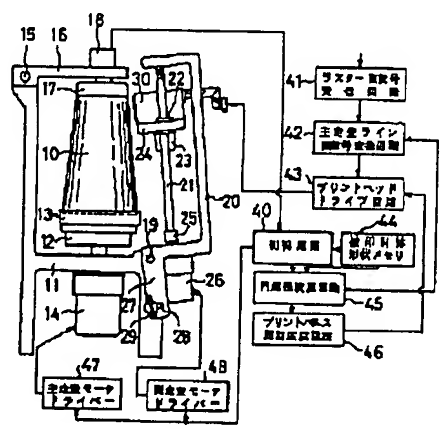
(54) CURVED SURFACE PRINTER

(57) Abstract:

PURPOSE: To print even on a material to be printed consisting of a deformed rotary body such as a sphere, a barrel, etc., by enabling curved surface printing to be performed at a low cost without generating waste matter.

CONSTITUTION: A material 10 to be printed is supported freely rotatably centering its axis with a rotary support mechanism equipped with a lower rotary base 12 having a support jig 13 and an upper presser disk 17. Besides, an ink jet printing head 30 is vertically movably supported with a subscanning support mechanism consisting of a lead screw 21, a guide rail, etc. Further, an opposed interval of the ink jet printing head 30 to a printing surface of a material 10 to be printed is so constructed as to be kept constant with a mechanism which controls an inclination angle of a printing head arm 20. Thereby, a main scanning and a subscanning for printing on the material 10 to be printed are certainly carried out without generating any inconvenience.



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(54) Title of the Invention: Curved Surface Printing Device

(57) Abstract

Purpose: To perform curved surface printing at a low cost without producing waste and to print on materials to be printed consisting of rotating bodies with varying diameters such as spheres, round weights, barrel shapes, etc.

Constitution: Along with supporting the material to be printed 10 such that it can freely rotate centered on its axis by means of a rotating support mechanism provided with a lower rotary base 12 having a support jig 13 and an upper presser disk 17, an inkjet print head 30 is supported such that it can move vertically by a secondary scan support mechanism comprising a lead screw 21 and a guide rail, and the constitution is such that the opposing space between the inkjet print head 30 and the printing surface of the material to be printed is held fixed by a mechanism for adjusting the angle of inclination of a print head arm 20. so that by this means main scanning and secondary scanning for printing on the material to be printed 10 can be carried out accurately without giving rise to any defects.

[Claims]

1. A curved surface printing device wherein there is provided a first support means for supporting materials to be printed consisting of rotating bodies with varying diameters that can rotate centered on their axes, a second support means for supporting an inkjet print head for spraying ink on the printing surface of said material to be printed and said material to be printed such that it can move relative to the axial orientation of this material to be printed, and a means for setting the opposing space between a curved print surface of said material to be printed and said inkjet print head such that it can be varied.

[Detailed Description of the Invention]

[0001]

[Field of Application in Industry] The present invention relates to a printing device provided with functions for performing curved surface printing on peripheral surfaces of materials such as cylinders, round weights, spheres, etc.

[0002]

[Prior Art] Conventionally, printing devices such as those in the following, for example, have been known for printing on three-dimensional curved surfaces such as cylinders, spheres, etc.

[0003] More specifically, there is, first of all, the application of silkscreen printing methods in typical devices. FIG. 8 shows the principles of this constitution. A cylindrical material to

be printed 100 is supported by rotating rollers 101 such that it can be rotated. A silkscreen printing plate 102 is arranged on the peripheral surface of this material to be printed 100 in a state of linear contact such that it can move in the direction of arrow A. Furthermore, a squeegee is disposed in a position on the upper side of the silkscreen print plate 102. In order to print on the peripheral surface of the material to be printed 100 with this constitution, ink 104 is supplied to the upper surface of the silkscreen plate 102, and in this state, with the squeegee 103 pressing the silkscreen print plate 100 to the surface of the material to be printed 100, the silkscreen print plate 102 is moved in the direction of arrow A. Thus, the material to be printed 100 is rotated by rotating rollers 101 in coordination with the movement of the silkscreen print plate 102, and by this means an ink image 105 corresponding to the print pattern on the silkscreen print plate 100 is printed over the entire surface of the material to be printed 100.

[0004] On the other hand, attention has recently been given to devices that use inkjet print heads as other printing devices that can perform curved surface printing. FIG. 9 shows the principles of this constitution. No. 110 is the material to be printed, and an inkjet print head 111 is disposed in a position opposed to the print surface of this material to be printed 110. This inkjet print head 111 is equipped with deflecting electromagnets 113 and 114. When printing is carried out, the excitation of deflecting electromagnets 113 and 114 is controlled by a control circuit not shown in the drawing, while moving the inkjet print head 111 relative to the material to be printed 110. Thus, the magnetized ink 115 spraying from the inkjet nozzles 112 is deflected by the deflecting electromagnets 113 and 114 and adheres to

the print surface of the material to be printed 110, and by this means the desired ink image 116 is printed and formed on the print surface of the material to be printed 110.

[0005]

[Problems to be Solved by the Invention] However, these conventional devices have the following problems that should be solved. More specifically, in the silkscreen printing device, first of all, a separate silkscreen print plate 102 must be manufactured prior to printing. Therefore, along with printing preparation requiring a large amount of time that labor, large-scale facilities are necessary. Furthermore, since a large amount of consumables is necessary, there is a problem in that the printing costs are comparatively high. Furthermore, there is a problem in that a large amount of waste materials such as the silkscreen plates, etc., is generated after printing, and processing this is troublesome.

[0006] On the other hand, in printing devices that use inkjet print heads, the plate is unnecessary, so preparation does not take time or labor, and furthermore, the facilities for manufacturing the plate or unnecessary. Therefore, it is possible to carry out printing with less cost than in the case of silkscreen printing. Furthermore, no waste is generated, so there are none of the headaches of that processing.

[0007] However, in these various devices conceived of conventionally, the material to be printed is typically held fixed, and the constitution is such that the inkjet print head moves within a plane parallel to the material to be printed. Therefore, the shape of the curves that can be printed is limited to quadratic surfaces with open flat surfaces and gentle curves, and it has been impossible to print on materials to be printed that are rotating bodies with varying diameters such as spheres, round weights, barrel shapes, etc.

[0008] The present invention focuses on the above facts, so it is an object to provide a curved surface printing device that can carry out curved surface printing inexpensively, without producing waste, and can print on materials to be printed consisting of rotating bodies with varying diameters such as spheres, round weights, barrel shapes, etc.

[0009]

[Means to Solve the Problems] A curved surface printing device according to the present invention that achieves the object mentioned above is provided with a first support means for supporting a material to be printed consisting of a rotating body with varying diameter such that it can rotate centered on its axis and be attached and removed and a second support means for supporting an inkjet print head that sprays ink on the print surface of the material to be printed mentioned above and the material to be printed mentioned above such that it can move relative to the axial orientation of this material to be printed, and furthermore provided with a means for setting an opposing space such that by this means for setting the opposing space it is possible to vary the opposing space between the print surface of the material to be printed mentioned above and the inkjet print head mentioned above.

[0010]

[Work or Operations of the Invention] As a result, according to the present invention, this material to be printed is supported by the first support means centered on its axis such that it can rotate and supported by the second support means so that it can move relative to the inkjet print head along the axial orientation, even if the material to be printed is a rotating body with a varying diameter such as a sphere, round weight, a barrel shape, etc.. and

furthermore, the opposing space between the print surface of the material to be printed and the inkjet print head is set, for example, to a fixed [distance] by the means for setting the opposing space. Therefore, along with being rotated by a drive mechanism including a motor, etc., the material to be printed and the inkjet print head are moved relative to each other along the axial orientation according to the image information to be printed, and the ink image corresponding to the image information mentioned above is printed and formed on substantially the entire print surface of the material to be printed consisting of a curved [character mistake in original] surface if the inkjet print head is driven.

[0011] Furthermore, since printing is directly carried out on the print surface of the material to be printed by the inkjet print head, it is possible for a print plate to be unnecessary and the amount of ink, etc., consumed is comparatively small. Therefore, curved surface printing can be done simply and inexpensively without the use of large-scale facilities in a short period of time. Furthermore, since waste such as the plate, etc., is not generated, it is possible to simplify the processing following printing.

[0012]

[Embodiments]

(First Embodiment) This embodiment describes a case wherein printing is carried out on the peripheral surface of the material to be printed with a shape, such as that of a cup, that is tapered along the axial orientation.

[0013] FIG. 1 is a schematic structural diagram of an inkjet curved surface printing device related to the present embodiment. The device in this embodiment comprises a support

mechanism part for the material to be printed 10, a support mechanism part for the inkjet print head 30, and a print drive circuit part.

[0014] First of all, the support mechanism part for the material to be printed 10 is constituted as follows. More specifically, 11 is a lattice shaped holding frame 11, and a lower rotary base 12 is axially supported on the upper surface part of the holding frame 11 pedestal. On the stand of this lower rotary base 12, there is attached a support jig 13 for affixing the material to be printed 10 such that it can be attached and released freely. Furthermore, the axis of rotation of the lower rotary base 12 mentioned above is connected to the drive shaft of the main scanning motor 14, and by this means the rotation of the lower rotary base 12 is driven by the main scanning motor 14. A pulse motor, servomotor or some other for which rotational position and rotational speed can be accurately controlled is used for the main scanning motor 14. Furthermore, an upper mobile frame 16 is mounted to the upper end of the support column for the holding frame 11 so as to be able to swing with a circular motion through a rotary shaft 15. An upper presser plate 17 is axially supported on this upper mobile frame 16. The axis of rotation of this upper presser plate 17 is set up on the same axis as the axis of rotation of the lower rotary base 12, and the upper presser plate 17, along with the lower rotary base 12 mentioned previously and a support jig 13, supports the material to be printed such that it can rotate. Furthermore, the rotating shaft of a rotary encoder 18 is connected to the axis of rotation of the upper presser plate 17 mentioned above. The rotary encoder 18 outputs a pulse for each rotation of the material to be printed 10.

[0015] On the other hand, the support mechanism part for the inkjet print head 30 is constituted as follows. More specifically, an print head arm 20 is mounted to the end of the pedestal part of the holding frame 11 mentioned above so as to be able to swing with a circular motion through rotary shaft 19. The lead screw it 21 is axially mounted within the U-shaped frame of this print head arm 20, and furthermore, a guide rail (not shown in the drawing) is disposed parallel to this lead screw 21. A print head support base 24 is attached to this lead screw 21 and guide rail by way of a female screw 22 and a slide bearing seat 23. The inkjet print head 30 is attached to this print head support base 24. The position for the attachment of this inkjet print head 30 on the print head support base 24 is movable, and the opposing space between the material to be printed 10 and the inkjet print head 30 is adjusted by this means.

[0016] Furthermore, the lead screw 21 mentioned above is connected to the drive shaft of the secondary scansion motor 26 through coupling 25. This secondary scansion motor 26 moves the inkjet print head 30 vertically by rotating the lead screw 21 previously mentioned. However, for example, single nozzle continuous types or on-demand type multiple nozzle types can be used for the inkjet print head 30 mentioned above. Furthermore, a pulse motor, servomotor or some other for which rotational position and rotational speed can be accurately controlled is used for the secondary scanning motor 26 mentioned above. A slide groove 28 is disposed on the base in the arm 27 of the print head arm 20 previously mentioned, and a holding screw 29 is screwed into the holding frame 11 mentioned above, engaging this slide groove 28. More specifically, it is possible to change

the angle of inclination of print head arm 20 to the holding frame 11 by means of this slide groove 28 and holding screw 29.

[0017] Furthermore, the print drive circuit part is provided with a control circuit 40, raster image signal receiving circuit 41, scanning line image signal conversion circuit 42, print head drive circuit 43, memory 44 for the shape of the material to be printed, circumference calculation circuit 45, print pulse cycle calculation circuit 46, main scan motor driver 47 and secondary scan motor driver 48.

[0018] Of these, the raster image signal receiving circuit 41, first of all, has a buffer memory or a page memory, and it takes up a print image raster image signal created separately using a scanner, video camera, or further, computer graphics functions. and stores this raster image signal in the buffer memory or page memory mentioned above.

[0019] The memory 44 for the shape of the material to be processed stores data related to the shape of the material to be printed. Graphic pattern design values or, for example, perimeter values in positions along each axis, obtained by actually measuring the shape of the material to be printed 10 are used for the data related to shape. Calculations of the circumference for each position of the material to be printed 10 along the axis are made in the circumference calculation circuit 45 based on the data related to the shape of the material to be printed 10 stored in the memory 44 for the shape of the material to be printed. This calculated circumference data is supplied to both the main scan line image signal conversion circuit 42 and the print pulse cycle calculation circuit 46.

[0020] Based on the circumference calculation data for the material to be printed 10 supplied by the circumference calculation circuit 45 mentioned above the main scan line

image signal conversion circuit 42 converts the main scan signal of the raster image signal saved by the raster image signal receiving circuit 41 mentioned above such that it conforms with the circumference of the material to be printed 10. In this case, if, for example, the raster signal main scan signal length is set so as to be compatible with a maximum circumference of the material to be printed 10, the amount of information is reduced by thinning out the main scan signal for raster signals that correspond to other parts on the periphery of the material to be printed 10, and by this means it is matched to the peripheral part of the material to be printed 10.

[0021] Calculation processing for converting the inkjet print head 30 print pulse cycle so as to be inversely proportional to the circumference of the material to be printed 10 for obtaining an even distribution of dots regardless of the circumference on the peripheral surface of the material to be printed 10 is carried out by the print pulse cycle calculation circuit 46.

[0022] The print head drive circuit 43 energizes the inkjet print head 30 according to the print image signal for which the main scan signal length was converted by the main scan line image signal conversion circuit 42 mentioned above and the print pulse for which the period was converted by the print pulse cycle calculation circuit 46 mentioned above.

[0023] Since the control circuit 40 has, for example, a microcomputer as the main control part, it controls the drive of both the main scan motor driver 47 and the secondary motor driver 48 in synchrony with the energizing operation for the inkjet print head 10 [sic] through the print head drive circuit 43 mentioned above. At this time, the main scan

rotation timing for the material to be printed 10 due to the main scan motor 14 is controlled based on the pulse output from the rotary encoder 18.

[0024] Next, the operation of a device constituted as in the above will be described. First, before printing, the material to be printed is supported so as to be sandwiched between the lower rotary base12 and the upper presser plate 17 by the opening and closing of the upper mobile frame 16. Furthermore, along with this, the data related to the shape of the material to be printed 10 mentioned above is saved in the memory 44 for the shape of the material to be printed, and further, a raster image signal created separately using a scanner, video camera, or further, computer graphics functions not shown in the drawing is input and saved in the raster signal receiving circuit 41.

[0025] If a start print instruction is input to the control circuit 40 in this state, the circumference for each position of the material to be printed 10 along each of the axes is calculated in the circumference calculation circuit 45 based on the data concerning the shape of the material to be printed 10 stored in the memory 44 for the shape of the material to be printed. Furthermore, the raster signal main scan signal length is converted in the main scan line image signal conversion circuit 42 so as to be compatible with the circumference of the material to be printed 10 saved in the raster image signal receiving circuit 41 mentioned above based on this calculated circumference data.

[0026] For example, raster image signals obtained from scanners, video cameras, etc., typically have a rectangular scan range as shown in FIG. 2 (a), and the scan pixel density is uniform across the entire scan range. Conversely, the peripheral shape of the material to be printed 10 has variations in the circumference along the axes as shown in FIG. 2 (b).

Therefore, the dots for the raster signal main scan signal are processed by thinning according to the circumference of the material to be printed in the main scan line image signal conversion circuit, and the raster image signal scan range that accompanies printing is converted such that it corresponds to the peripheral surface shape for the material to be printed 10 as shown in FIG. 2 by this means. However, when there is simple compression where there is matching of the raster image signal main scan line length with the shape of the material to be printed without thinning the image signal dots, the ink adherence density becomes greater, so the image density becomes too great, and the print image becomes unclear, and in some cases the hardening of the ink is slower, so problems such as the ink running arise.

[0027] Furthermore, calculation processing for converting the inkjet print head 30 print pulse cycle so as to be inversely proportional to the circumference of the material to be printed 10 for obtaining an even distribution of dots regardless of the circumference on the peripheral surface of the material to be printed 10 is carried out by the print pulse cycle calculation circuit 46. For example, each of the calculations is performed so that the print pulse cycle is short for the large diameter part of the material to be printed 10 and the print pulse cycle is long for the small diameter part of the material to be printed 10, and by this means, the print pulse cycle is set to correspond to the shape of the material to be printed 10.

[0028] Furthermore, when the main scan signal conversion and print pulse cycle setting have been completed, drive instructions are given for the main scan motor driver 47 and the secondary scan motor driver 48 from the control circuit 40, and by this means, the

rotational operations of the main scan motor 14 and secondary scan motor 26 are started. Furthermore, a drive signal corresponding to the print image signal converted above is given in accordance with the print pulse cycle set above for the inkjet print head 30 by the print head drive circuit 43 in synchrony with these rotational operations, and by this means the inkjet print head 30 is energized. Therefore, an image corresponding to the print image signal discussed above is printed and formed on the peripheral surface of the material to be printed 10.

[0029] Thus, in the present embodiment, the constitution is such that, along with the material to be printed 10 being supported so as to be able to rotate centered on its axis by a rotating support mechanism provided with a lower rotary base 12 having a support jig 13 and an upper presser disk 17, the inkjet print head 30 is supported such that it can move vertically by a secondary scan support mechanism consisting of a lead screw 21 and a guide rail, and it is supported such that the opposing space between the print surface of the material to be printed 10 and the inkjet print head is fixed by a mechanism that adjusts the angle of inclination of the print head arm 20. Therefore, it is possible to accurately carry out the main scanning and secondary scanning for printing on the material to be printed 10 without the occurrence of any trouble, and by this means it is possible to spray ink and print images without leakage from an inkjet print head 30 over the entire peripheral surface of the material to be printed 10 having a cup shape that has linear changes in diameter along the axial orientation.

[0030] Furthermore, since an inkjet printing method is used for the printing method, printing is done directly on the peripheral surface of the material to be printed 10 by the

inkjet print head. Therefore, it is possible for printing plates to be unnecessary and get by with comparatively low consumption of ink, etc. Therefore, curved surface printing can be done simply and inexpensively without the use of large-scale facilities in a short period of time. Furthermore, since waste such as the plate, etc., is not generated, it is possible to simplify the processing following printing.

[0031] Furthermore, the constitution is such that, when the inkjet print head 30 is driven in the present embodiment, along with conversion of the original raster image signal main scan signal by the main scan line image signal conversion circuit 42 according to the shape of the material to be printed 10, the settings can be varied in accordance with the shape of the material to be printed 10 mentioned previously by the print pulse cycle calculation circuit 46. Therefore, regardless of the changes in the circumference of the peripheral surface of a material to be printed 10 consisting of a cup shape, the image is printed and formed in accordance with the original raster image signal with uniform dots and without distortion.

[0032] (Second Embodiment) In this embodiment, the case of printing on the peripheral surface of a material to be printed with a so-called barrel shape, where the diameter is greatest at the center along the axial orientation and gradually decreases toward the ends will be described.

[0033] FIG. 3 is a schematic structural diagram of an inkjet curved surface printing device related to the present embodiment. Here, the parts in this drawing that are the same as those previously described in FIG. 1 are given the same numbers and detailed descriptions are omitted.

[0034] A lattice shaped rotating frame 53 is attached so as to be able to swing with a circular motion through rotary shaft 52 to holding frame 51. There is axial support on the lower end of this rotating frame 53 for a rotary base 54 and on the upper end for a presser disk 55. By sandwiching both ends of the barrel shaped material to be printed 50 between this rotary base 54 and presser disk 55, this material to be processed 50 is supported so as to rotate freely in the rotating frame 53. A main scan motor 14 is connected to the axis of rotation 59 of the rotary base 54 mentioned above, and rotation is driven by this main scan motor 14. A rotary gear 56 is axially mounted on the rotary shaft 52 mentioned above, and the teeth of this rotary gear 56 are meshed with those of a drive gear 57. The shaft of this drive gear 57 is connected to a gap adjustment motor 58. The gap adjustment motor 58 rotates the rotating frame 53 through the drive gear 57 and the rotary gear 56 mentioned above to maintain a fixed opposing space between the peripheral surface of the material to be printed 50 and the inkjet print head 30 that will be discussed later.

[0035] On the other hand, the support mechanism for the inkjet print head 30 has a lead screw 21 and a guide rail as discussed with FIG. 1. A print head support base 24 is attached to this lead screw 21 and guide rail by way of a female screw 22 and a slide bearing seat 23, and the inkjet print head 30 is attached to this print head support base 24. Furthermore, the lead screw 21 mentioned above is connected to the drive shaft of the secondary scan motor 26 through a coupling. This secondary scan motor 26 moves the inkjet print head 30 vertically by rotating the lead screw 21 previously mentioned.

[0036] Furthermore, in addition to the raster image signal receiving circuit 41, the main scan line image signal conversion circuit 42, print head drive circuit 43, memory 44 for the

shape of the material to be processed, circumference calculation circuit 45, main scan motor driver 47, and secondary scan motor driver 48, there are provided a control circuit 400, a gap adjustment motor driver 49 and a main scan rotary speed instruction circuit 401.

[0037] The control circuit 400 is synchronized with the energizing operation for the inkjet print head 10 by the print head drive circuit 43 mentioned above, and [it] controls the driving of both the secondary scan motor driver 48 and the gap adjustment motor driver 49. The gap adjustment motor driver 49 drives the rotation of the gap adjustment motor 58 according to the drive control signal supplied by the control circuit 400.

[0038] The rotary speed of the main scan motor 14 is converted in the main scan rotary speed instruction circuit 401 to a speed inversely proportional to the circumference of the material to be printed 50 based on the calculated circumference data for the material to be printed 50 supplied by the circumference calculation circuit 45 in order to distribute the print dots uniformly regardless of the circumference of the peripheral surface of the material to be printed 50, and this converted speed is given as an instruction to the main scan motor driver 47. However, ink is sprayed according to a fixed print pulse cycle regardless of the peripheral surface shape of the material to be printed 50 by the print head drive circuit 43.

[0039] Because there is this constitution, a barrel shaped material to be printed 50 is held on the rotary base by the pressure of the presser disk 55 and by this means is supported in a state making possible the rotation necessary for the main scan. Furthermore, the material to be printed 50 is supported by the rotating frame 53 such that it rotates freely, and by this means the space between [it] and the inkjet print head 30 can be adjusted to remain fixed.

On the other hand, the inkjet print head 30 is supported by the lead screw 21 and guide rail in a state that makes possible the vertical movement for the secondary scan.

[0040] In this state, the data related to the shape of the material to be printed 50 mentioned above is saved in the memory 44 for the shape of the material to be printed, and a raster image signal created separately using a scanner, video camera, or further, computer graphics functions not shown in the drawing is input to the raster signal receiving circuit 41. Therefore, calculations of the circumference for each position of the material to be printed 50 along the axis are first made in the circumference calculation circuit 45 based on the data related to the shape of the material to be printed 50 stored in the memory 44 for the shape of the material to be printed. Next, the raster signal main scan signal length is converted so as to be compatible with the circumference of the material to be printed 50 saved in the raster image signal receiving circuit 41 mentioned above in the main scan line image signal conversion circuit 42 based on this calculated circumference data. For example, when there is a rectangular scan range as shown in FIG. 4 (a) and the scan pixel density is uniform across the entire scan range, reduction processing is carried out suitably by thinning out the dots in the main scan signal and expansion processing by inserting dots according to the circumference of the material to be processed 50 (FIG. 4 (b)), and by this means the raster signal is converted to a shape corresponding to the peripheral surface shape of the material to be printed 50 as is shown in FIG. 4 (c).

[0041] Furthermore, once this print image signal is obtained, a drive signal is supplied to the inkjet print head 30 from the print head drive circuit 43 in accordance with the print

signal described above, and by this means, the inkjet print head 30 begins spraying ink according to a fixed print cycle.

[0042] On the other hand, a drive control signal for the main scan motor driver 47 that is synchronized with this inkjet print head 30 energizing operation is supplied by the main scan rotary speed instruction circuit 401. Furthermore, at this time, a speed instruction signal such that the rotational speed of the main scan motor 14 is inversely proportional to the circumference of the material to be printed 50 is supplied to the main scan motor driver 47 by the main scan rotary speed instruction circuit 401. Therefore, the main scan motor 14 performs rotational operation in accordance with the circumference of the material to be printed 50, such that the speed of rotation is fastest when printing is being performed at the ends of the material to be printed 50 and the speed of rotation is the slowest when printing is being performed at the center of the material to be printed 50. Therefore, fixed dot printing is always carried out regardless of the circumference of the peripheral surface of the material to be printed.

[0043] Furthermore, the drive control signal for the secondary scan is supplied to the secondary scan motor driver 48 by the control circuit 400, and by this means the secondary scan motor 26 begins rotation at a fixed speed. Therefore, the inkjet print head 30 performs a secondary scan of the peripheral surface of the material to be printed 50 at a fixed speed. Furthermore, the drive control signal is supplied to the gap adjustment motor driver 49 by the control circuit 400 for adjusting the gap, and by this means, the gap adjustment motor 58 carries out rotational operation such that it is possible to vary the rotational orientation

during the process. Therefore, the gap between the peripheral surface of the material to be printed 50 and the inkjet print head 30 is always maintained substantially fixed.

[0044] In this embodiment, the constitution is one wherein, along with supporting a barrel shaped material to be printed 50 such that it can rotate centered on its axis by a rotating support mechanism including a rotary base 54 and a presser disk 55, the inkjet print head 30 is supported such that it can move vertically by a secondary scan support mechanism consisting of a lead screw 21, guide rail, etc.. and the material to be printed 50 is supported by a rotating frame 53 and a rotary drive mechanism such that it can rotate. Therefore, it is possible to accurately perform the main scansion and secondary scansion for printing on a barrel shaped material to be printed 50, and it is possible to maintain a substantially fixed gap between inkjet print head 30 and the material to be printed 50. Therefore, it is possible to spray ink and print images without leakage from an inkjet print head 30 over the entire peripheral surface of the barrel shaped material to be printed 50.

[0045] Furthermore, as in the first embodiment previously described, the peripheral surface of the material to be printed 50 is directly printed by the inkjet print head 30. Therefore, it is possible for printing plates to be unnecessary and get by with comparatively low consumption of ink, etc. Therefore, curved surface printing can be done simply and inexpensively without the use of large-scale facilities in a short period of time. Furthermore, since waste such as the plate, etc., is not generated, it is possible to simplify the processing following printing.

[0046] Furthermore, it is such that, when the inkjet print head 30 is driven in the present embodiment, the original raster image signal main scan signal is converted by the main

scan line image signal conversion circuit 42 according to the shape of the material to be printed 50, and the setting of the main scan speed can be varied in accordance with the shape of the material to be printed 50 mentioned previously by the main scan rotary speed instruction circuit 401. Therefore, regardless of the changes in the circumference of the peripheral surface of the barrel shaped material to be printed 50, the image is printed with high quality in accordance with the original raster image signal with uniform dots and without distortion.

(Third Embodiment) This embodiment describes a case wherein printing is carried out on the peripheral surface of a spherical material to be printed.

[0047] FIG. 5 is a diagram showing the main parts of the constitution of an inkjet curved surface printing device related to the present embodiment. In the figure, 61 of is a U-shaped holding frame, and a rotating frame 63 having a lattice shape is attached to this holding frame 61 through a rotary shaft 62 such that it can rotate. On the two opposed sides of this rotating frame 53 [sic], a rotary base 64 and a presser disk 65 are supported axially, and the spherical material to be printed 60 is held sandwiched between this rotary base 64 and presser disk 65. The drive shaft of a main scan motor 66 is connected to the axis of rotation of the rotary base 64 mentioned above, and rotation is driven by this main scan motor 66. Furthermore, a rotary gear 67 is axially mounted on the rotary shaft 62 mentioned above, and the teeth of this rotary gear 67 are meshed with those of a drive gear not shown in the drawing. This rotary gear 67 and drive gear transfer the drive force of a secondary scansion motor not shown in the drawing to the rotary shaft 62 mentioned above, and by this means, circular motion is provided to the rotating frame 63 in relation to the holding frame 61.

However, the inkjet print head 30 is disposed in a fixed manner in a state with a prescribed gap with the peripheral surface of the material to be printed 60.

[0048] Since the constitution is as such, the material to be printed is supported by the rotary base 64 and presser disk 65 such that it can rotate, and in this state rotation is driven in the direction of arrow x by the main scan motor 66. In other words, the main scanning for printing is carried out by this means. However, the rotational speed of the main scan motor 66 at this time undergoes variable control according to the circumference of the material to be printed 60 such that printing is performed with a fixed dot density regardless of the circumference of the material to be printed 60. Furthermore, rotation of the rotating frame 63 is driven in direction of arrow y by a secondary scan motor not shown in the drawing in synchrony with the main scan described above, and by this means, secondary scanning for printing is carried out.

[0049] Therefore, having the present embodiment, it is possible to carry out the desired printing using an inkjet print system over substantially the entirety of the peripheral surface of a spherical material to be printed 60.

[0050] However, the present invention is not limited to the embodiments described above. For example, in the first and second embodiments, it was such that design data or data measured separately was saved in the memory 44 for the shape of the material to be processed as data related to the shape of materials to be printed 10 and 50. However, as another system, there could be a constitution such that a shape sensor could be attached to the print head support base 24, and the shape of the peripheral surface of the material to be printed 10 and 50 could be measured by this shape sensor as printing is being carried out

based upon this measured data. Given this constitution, the work of measuring the shape of the material to be printed 10 and 50 and storing it in the memory 44 in advance would be unnecessary, and it would be possible to simplify and reduce the time for printing by this means and provide a device for highly efficient printing.

[0051] Furthermore, in the first and second embodiments, the constitution was such that the support mechanism parts for the material to be printed 10 and 50 and the support mechanism parts for the inkjet print head 30 are situated perpendicular to each other, and secondary scanning was carried out by moving inkjet print head 30 vertically. However, there may be a constitution such that the support mechanism parts for the material to be printed 10 and 50 and the support mechanism parts for the inkjet print head 30 are situated parallel to each other, and in this state the inkjet print head 30 is moved horizontally. When, for example, and a multi-nozzle type on demand form is used for the inkjet print head, restrictions arise in the orientation of the ink containers, the secondary arrangement of orifices, etc., and this is spatially impossible to implement with the constitutions in the first and second embodiments described above. However, with a constitution such that the entirety of the support mechanisms is arranged parallel as in the above and the inkjet print head 30 performs a secondary scan in a horizontal orientation, implementation is possible with the restrictions mentioned above.

[0052] Furthermore, when there is a constitution such that, in the first embodiment, the inkjet print head 30 is a multi-nozzle type and a belt-shaped scanning range is formed from a plurality of lines in the orientation of the secondary scan for each rotation of the material to be printed 10 and printing progresses in a spiral connection of these, the print scansion

lines are formed so as to move at a slant through the coordinates of the original raster image signal. Therefore, the main scan line image signal conversion circuit 42 may carry out a conversion for a spiral scan in this case.

[0053] FIG. 6 is a diagram for explaining this relationship. In the figure, the line indicated by the dashed line l1 - l8 (ln) is the main scan line in the original raster image signal. Conversely, the line indicated by the solid line L1 – L4 is the print dot line from the inkjet print head 30, and in this example, the case wherein four nozzles operate at the same time and form a spiral scansion range is shown. To generate the print image signal that corresponds to this print dot line, there may be conversion processing such that the nearest address position for offsetting lines L1 – L4 is extracted from the image signal in the memory space comprising lines l1 – ln and rearranged in the main scan line image signal conversion circuit 42 mentioned above.

[0054] Furthermore, in the first embodiment, the constitution may be such that that the support jig 13 is disposed on the lower rotary base 12 and the material to be printed 10 is affixed by means of this support jig 13, while the constitution is one wherein the lower rotary base 12 is provided with a chuck mechanism with an adjustable function and by this means the material to be printed is directly affixed to the lower rotary base 12.

[0055] Furthermore, in the second embodiment, it is such that the gap between the inkjet print head 30 and the material to be printed 50 is adjusted by rotating the material to be printed 50, but instead of this, the constitution may be such that a mechanism for moving the inkjet print head 30 backward and forward is disposed on the print head support base

24, and the gap between the inkjet print head 30 and the peripheral surface of the material to be printed 50 is adjusted by this mechanism.

[0056] FIG. 7 shows an example of such a constitution, so 240 represents the print head support base. A movable base 243 that makes possible sliding by means of a slide rail 242 is disposed on the base 241 of this print head support base 240. The inkjet print head 30 is disposed fixedly on this movable base 243. Furthermore, a female screw 244 is affixed to the bottom surface of the movable base 243 mentioned above, and the lead screw 245 is screwed together with his female screw 244. The base end of this lead screw 245 is connected to the drive shaft on a motor 247 through a joint 246. This motor 247 is driven by and motor drive or not shown in the drawing according to control by a control circuit.

[0057] Because of this constitution, the lead screw 245 rotates according to the rotation of this motor 247 with control of the direction of rotation and amount of rotation of motor 247 corresponding to the vertical movement of the inkjet print head 30 during a printing operation, and by this means the movable base 243, that is the inkjet print head 30, moves backward and forward. Therefore, if the amount of this backward and forward motion is set suitably, it is possible to maintain a substantially fixed space between the peripheral surface of the material to be printed 50 and the inkjet print head 30.

[0058] Furthermore, in the third embodiment, the inkjet print head 30 is disposed in a fixed manner, but secondary scanning may also be carried out by moving this inkjet print head 30. In order to achieve this, for example, there may be a constitution wherein the rotating frame 63 is fixed, and the arm supporting the inkjet print head 30 supported by the rotating

shaft 62 through a position centered on the material to be printed 60, with this arm driven by a motor.

[0059] Furthermore, in the third embodiment, the spherical material to be printed 60 is held in a state sandwiched between the rotary base 64 and the presser disk 65 and rotated for the main scan. However, in this case, the part of the peripheral surface of the material to be printed 60 that is in contact with the rotary base 64 and the presser disk 65 cannot be printed. Therefore, there may be a constitution wherein the material to be printed 60 is attached to a rotating shaft in advance, and this rotating shaft is axially supported and rotated. With this constitution, substantially all of the peripheral surface of the material to be printed 60 can be printed without leakage.

[0060] Besides these, various modifications such as constitutions for shapes of the material to be printed and support mechanisms for them, constitutions for inkjet print head support mechanisms, constitutions for a means for setting the opposing space to make the setting for the opposing space between the curved print surface of the material to be printed and the inkjet print head variable, and various types and constitutions of inkjet print heads may be implemented in a range that does not deviate from the gist of the present invention.

[0060]

[Effects of the Invention] As described above, the present invention is one wherein curved surface printing device according to the present invention is provided with a first support means for supporting a material to be printed consisting of a rotating body with varying diameter such that it can rotate centered on its axis and be attached and removed and a second support means for supporting an inkjet print head that sprays ink on the print

surface of the material to be printed mentioned above and the material to be printed mentioned above such that it can move relative to the axial orientation of this material to be printed, and furthermore provided with a means for setting an opposing space such that by means of this means for setting the opposing space it is possible to vary the opposing space between the print surface of the material to be printed mentioned above and the inkjet print head mentioned above.

[0008] Therefore, according to the present invention, there can be provided a curved surface printing device that can carry out curved surface printing inexpensively, without producing waste, and can print on materials to be printed consisting of rotating bodies with varying diameters such as spheres, round weights, barrel shapes, etc.

[Brief Description of the Drawings]

FIG. 1 is a schematic structural diagram of an inkjet curved surface printing device related to a first embodiment of the present invention.

FIG. 2 is a drawing used to explain the operation of the device shown in FIG. 1.

FIG. 3 is a schematic structural diagram of an inkjet curved surface printing device related to a second embodiment of the present invention.

FIG. 4 is a drawing used to explain the operation of the device shown in FIG. 3.

FIG. 5 is a schematic structural diagram of an inkjet curved surface printing device related to a third embodiment of the present invention.

FIG. 6 is a pattern diagram for explaining an example of a modification to the present invention.

FIG. 7 is a drawing showing the constitution of an inkjet print head support mechanism part related to an example of another modification to the present invention.

FIG. 8 shows in principle the constitution of a conventional curved surface printing device using a silkscreen printing method.

FIG. 9 shows in principle the constitution of a conventional curved surface printing device using an inkjet print head.

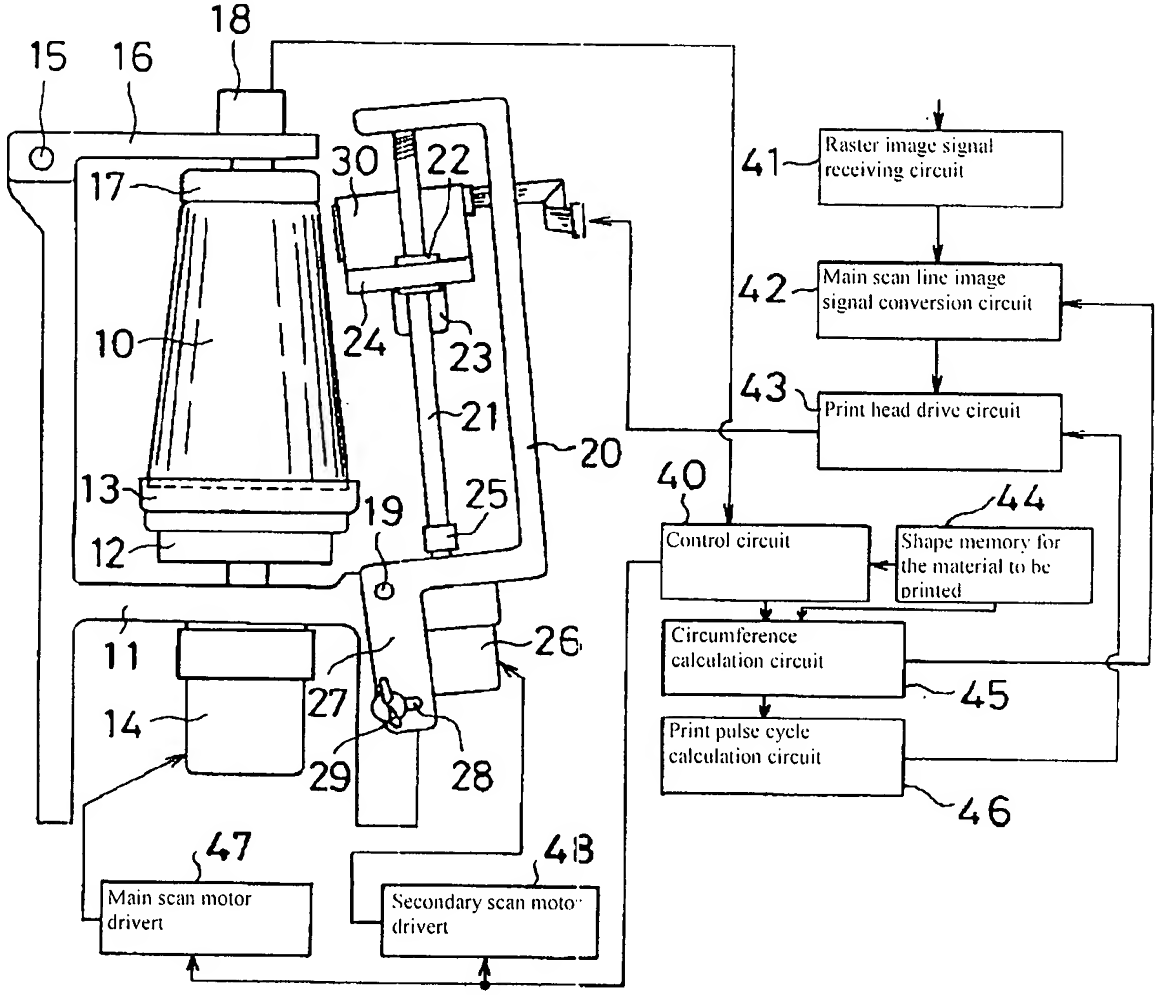
[Explanation of the Reference Numbers]

10, 50, 60,	Material to the printed
11	Holding frame
12	Lower rotary base
13	Support jig
14	Main scan motor
15	Rotary shaft
16	Upper mobile frame
17	Upper presser disk
18	Rotary encoder
19	Rotary shaft
20	Print head arm
21	Lead screw
22	Female screw
23	Slide bearing seat

24	Print head support base
25	Coupling
26	Secondary scan motor
27	Arm base
28	Slide groove
29	Holding screw
30	Inkjet print head
40, 400	Control circuit
41	Raster image signal receiving circuit
42	Main scan line image signal conversion circuit
43	Print head drive circuit
44	Shape memory for the material to be printed
45	Circumference calculation circuit
46	Print pulse cycle calculation circuit
47	Main scan motor driver
48	Secondary scan motor driver
49	Gap adjustment motor driver
51	Holding frame
52	Rotary shaft
53	Rotating frame
54	Rotary base
55	Presser disk

56	Rotary gear
57	Drive gear
58	Gap adjustment motor
401	Main scan rotary speed instruction circuit
61	Holding frame
62	Rotary shaft
63	Rotating frame
64	Rotary base
65	Presser disk
66	Main scan motor
67	Rotary gear
240	Print head support base
241	Base
242	Slide rail
243	Movable base
244	Female screw
245	Lead screw
246	Joint
247	Motor

FIG. 1



Raster image signal receiving circuit
Main scan line image signal conversion circuit
Print head drive circuit
Control circuit
Shape memory for the material to be printed
Circumference calculation circuit
Print pulse cycle calculation circuit
Main scan motor drivert
Secondary scan moto·· drivert

FIG. 5

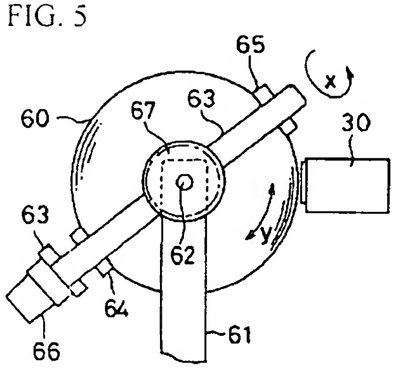


FIG. 6

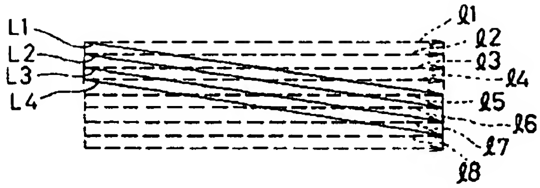


FIG. 8

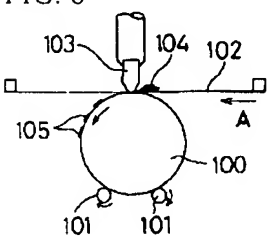


FIG. 2

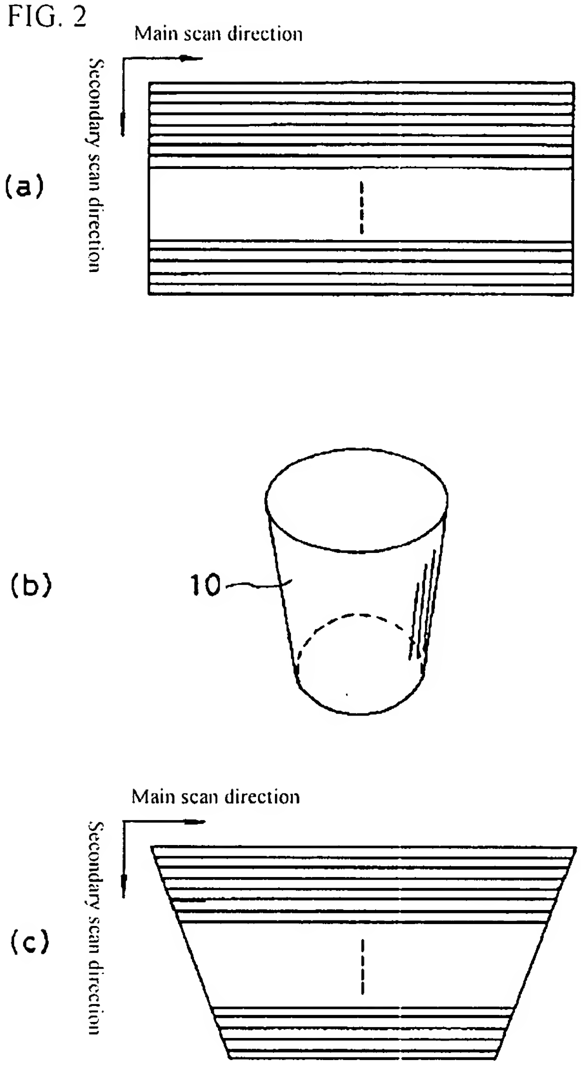
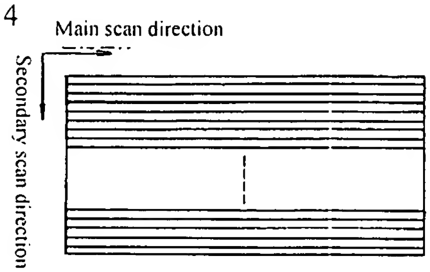
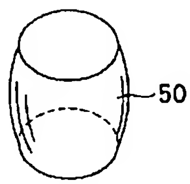

Main scan direction
Secondary scan direction
(a)
(b)
10
Main scan direction
Secondary scan direction
(c)

FIG. 4

(a)



(b)



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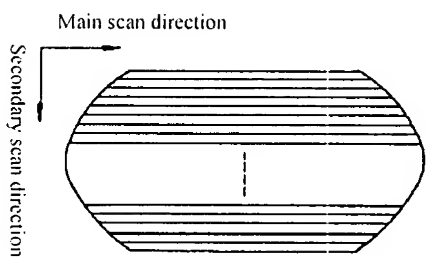

FIG. 7

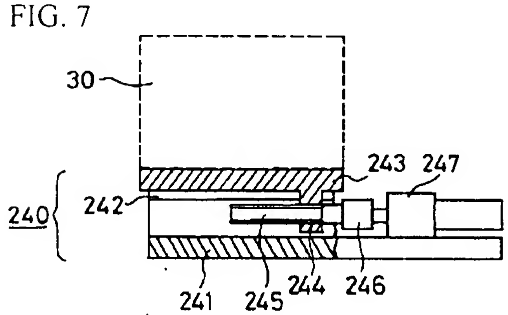

FIG. 9

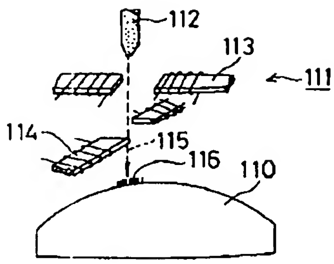
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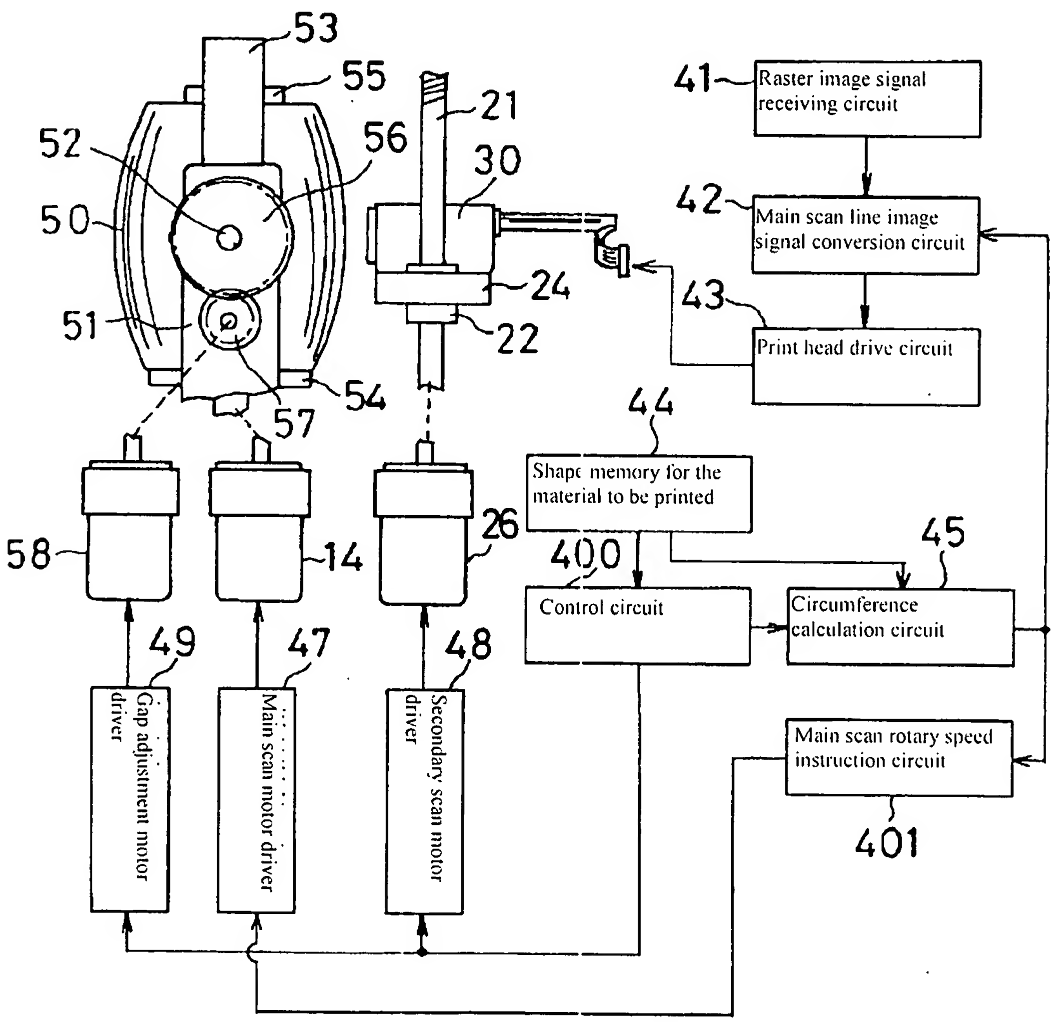
FIG. 3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Raster image signal receiving circuit
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Shape memory for the material to be printed
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400
Control circuit
Circumference calculation circuit
Main scan rotary speed instruction circuit
401
49
47
48
Gap adjustment motor driver
Main scan motor driver
Secondary scan motor driver

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This is to certify that the attached is, to the best of our knowledge and belief, a true and accurate translation from JAPANESE into ENGLISH

Mary Samaras
Mary Samaras, Assistant Director
inlingua Translation Service

NOTARIZATION

Sworn to before me on this 21 *day of* October, 2003.

Barbara E. McCarron
Notary Public

My commission expires 10.7.2005.

BARBARA E. McCARRON
Notary Public
My Commission Expires
October 7, 2005

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